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LOW-FREQUENCY VARIABILITY AND CROSS-FRONT EXCHANGE PROCESSES AT SHELF-BREAK FRONTS

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LONG-TERM GOAL

The long-term goal of this project is to understand the physical processes that control the low-frequency variability of and exchange of water masses, properties, and materials across shelf-break fronts.

OBJECTIVE

The near-term objectives are to gain fundamental insights into the role of mixed baroclinic / barotropic instabilities and the bottom boundary layer in the evolution of the shelf-break front density structure, eddy formations, and cross-front exchange.

APPROACH

A high resolution primitive equation numerical model is being applied to a series of idealized experiments representative of typical winter and summer conditions found at the shelf-break in the Mid-Atlantic Bight. Tracers (both passive and active) and simulated Lagrangian parcels are used to estimate the exchange across the front. The times and regions of exchange will be related to simple linear theories of the expected mechanisms of exchange, including eddy formation by frontal instabilities, chaotic mixing, and transport in the bottom boundary layer. The sensitivity of the exchange processes to physical parameters (topography, stratification, friction) will be investigated.

TASKS COMPLETED

The Semi-Spectral Primitive Equation Model (SPEM) has been configured in open boundary and periodic domains. Calculations have been carried out for both summer- and winter-like conditions. Various models for a barotropic shelf current and baroclinic shelf-break front current are being tested. Diagnostic routines in both isopycnal and frontal coordinates have been developed.

A theory which predicts the parameter dependence and the amplitude of the eddy heat flux across narrow frontal regions has been developed (Spall and Chapman, 1997). The theory has been tested with primitive equation numerical model calculations representative of the spin-down of a baroclinic front and the equilibration of local surface cooling by lateral eddy fluxes.

SCIENTIFIC RESULTS

The primary scientific result in the first year of this project is the theoretical estimate of cross front heat flux by baroclinic eddies. The parameter dependence predicted by the theory is the same as previous estimates derived from scaling arguments, however the present approach also provides a quantitative estimate of the amplitude of the eddy heat flux and a clearer understanding of the dynamics that control and lateral heat transport by baroclinic eddies.

IMPACTS FOR SCIENCE

Understanding the dynamics of lateral eddy heat fluxes in these idealized situations provides a building block for understanding and parameterizing the role of eddy fluxes in more complex flows.

RELATIONSHIP TO OTHER PROGRAMS

The frontal processes studied here are relevant to a number of other ONR, NSF and NOAA programs. Cross front exchange mechanisms and low-frequency variability are relevant to the ONR funded PRIMER experiment on shelf-break frontal processes and the coupled physical/biological processes that are the focus of GLOBEC. Understanding and parameterizing the lateral transport of heat by eddy fluxes is a focus of ongoing studies in the Labrador Sea and elsewhere (ONR, NOAA/NSF Atlantic Circulation and Climate Experiment (ACCE)).

REFERENCES

Spall, M. A. and D. C. Chapman. On the efficiency of baroclinic eddy heat transport across narrow fronts. submitted to: J. Phys. Oceanogr.